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ABSTRACT

Presented are performance objectives for Michigan elementary and secondary teachers of science. The objectives are to assist in the development of scientifically literate citizens as suggested by the National Science Teachers Association. The book is arranged according to grade levels. Each level is presented with an introduction to the grade level and a set of performance objectives for each. A glossary appears at the back. Members of the Task Force for the Development of Basic Science Objectives for Michigan are listed. (SA)

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minimal performance objectives for Science education in michigan

Michigan Department of Education

SE 029 040

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MICHIGAN DEPARTMENT OF EDUCATION
LANSING, MICHIGAN

JOHN W. PORTER
STATE SUPERINTENDENT
OF PUBLIC INSTRUCTION

In building educational objectives in science for elementary and secondary grade levels, the State Department of Education asked the Metropolitan Detroit Science Teachers Association (MDSTA), the Michigan Association of Science Education Specialists (MASES), and the Michigan Science Teachers Association (MSTA) to nominate persons to serve on committees for development of science goals and evaluational materials. The elementary and secondary committees which were formed in this way had overlapping membership. Although all grade levels were considered by the committees in attacking the problem, the work was finally brought to focus at the third, sixth, and ninth grade levels.

The Grade Level Commissions whose members include 168 parents, students, teachers, clergymen, etc., reviewed the document on November 10, 1972. After extensive revision, the Commissions approved the document on February 20, 1973. Several members of the Commissions did extended work on the objectives and their names are listed with the consultants (Attachment C). The Council for Elementary and Secondary Education made further revisions and approved the Science Objectives on March 20, 1973. The State Board of Education approved the Science Objectives on May 29, 1973. Special thanks are extended to the members of the various groups representing citizens and educators for their excellent contribution to this document.

The committees tried to balance process and product — what children learn and how they learn it. They attempted furthermore to carry this "process-product" interaction into the affective domain.
They first developed specific goals, and then stated these in terms of performance objectives. The performance objectives were then expanded in terms of examples from which sample test items could be developed.

The final result of this extended "process-product" development was an educational framework which is in harmony with the common goals of Michigan education. It should be understood that the performance objectives which the committees set, and any evaluation program which is based on them, must be thought of as a minimal attainment. Student attainment beyond this minimum is hoped for and expected.

Although the performance objectives, especially at the earlier levels, emphasize the domains of knowledge and skills, the domain of understandings and attitudes is brought more and more into the picture at later levels. By working out the examples at each level, and other experiences related to them, the students practice thinking, gain understandings, and form attitudes. Concept formation develops naturally with the attainment of a greater degree of maturity.

The third grade objectives deal mainly with fundamental processes. The sixth grade objectives deal with more complex processes and begin to introduce content, understandings, and attitudes which are relevant to the objectives.

The people who pay the taxes to support the schools are rightly demanding to know what they are getting for their money. The movement toward accountability in the schools is nationwide. Accountability makes assessment necessary. The committees believe that the goals and objectives which have been set will form a dependable basis for the construction of a meaningful science curriculum and testing instruments which will reflect students' minimal attainment in Michigan. The local school districts can use these objectives as a foundation for developing their own science program.

The Michigan Department of Education extends its appreciation to the thousands of teachers, administrators, consultants, and others who influenced the extensive revisions of science goals and objectives. Numerous meetings were held throughout Michigan where educators took time from busy schedules to react to the science objectives as they were being developed and refined

Thanks are also due to the Advisory Committee (attachment A) for writing and revising the objectives, to the workshop team who produced the test examples (attachment B) and to consultants who rigorously reviewed the working drafts (attachment C).

John W. Porter
Superintendent of Public Instruction

January 1974

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FORMAT OF THIS PROJECT

1. "In bold-face type are listed the topics under which the program objectives have been classified . . ." Achievement of these objectives is felt to be the over-all aim of the school science program.
2. Subsumed under the performance objectives are examples of more specific objectives that might permit one to decide whether or not a science program had achieved its purpose. In many cases, other performances could be used, either in place of the one given, or in addition to it, to provide additional evidence of program achievement.
3. The right-hand column contains sets of illustrations of the type of items which could be developed for use in an instrument related to the assessment of a performance objective. They are not examples from a test. Clearly much care needs to be taken in the development of an actual test instrument and it should include other performance objectives. The multiple-choice format might be selected; in fact, a paper and pencil test might not be the most suitable device for assessing every expected outcome of a program. In such situations, other illustrations and items would be required.
4. The fourth column (the delivery system) is not included in this publication since it was felt that schools should have the flexibility of selecting or developing their own programs and teaching strategies relevant to the needs* of their community and children. Teachers should ask the question "What activities or strategies are necessary in order for the learner to know or do that which is specified in the performance objectives?" Teachers are the experts and will immediately think of a number of excellent classroom activities for each of the objectives (or could relate an existing program to the objectives). This leaves the teacher free to use a variety of methods and strategies to meet the objectives. Schools select concepts by grade level that accomplish the process objectives. This then is the balance of process and product (concepts) which reflects the philosophy of most science educators today.

The methods and strategies of science education should include much more than the mere reading of a science textbook. It should involve learners in thinking skills and/or activities that will accomplish the major goal of education as suggested by the National Science Teachers Association:

*"Our goal of science education is to develop scienficially literate citizens with the necessary intellectual resources, values and attitudes and inquiry skills to promote the development of a man as a rational human being."**

*Needs refers to the third step of the Accountability Model as expressed in the Department of Education publication entitled *The Common Goals of Michigan Education.*

*Taken from the NSTA publication entitled, "The Science Teacher" 1971.

GRADES ONE - THREE

Introduction

These objectives, performance descriptions and illustrative assessment items are intended to serve as guidelines to the expected science performance of children at the end of their fourth year of schooling. They are called grade three objectives, and they represent not only the cumulative experience of third graders, but also the individual skills and behaviors which children might exhibit at the end of grades one and two.

The origin of these objectives can be found in the statement of *The Common Goals* of *Michigan Education*[1] and their development has involved school teachers, lay persons, and professionals in the fields of education and science. The consistent aim of these people has been to produce a set of useful guidelines for the assessment of the effects of school programs of children. They were not concerned entirely with measuring the situation, as it is now, or as it was in the past. They were, instead, seriously attempting to reflect the most reasonable minimum performances by children who are engaged in a quality science program and who enjoy the help of a competent instructor. It is especially important to note that the program is not free of "content", for direct knowledge of his environment is important to any person. On the other hand, the emphasis is clearly on "process", for that most closely approximates the nature of science as the developers saw it. Dr. Obourn said, "Science is a way of life,"[2] and we agree. In fact, it is one of the styles of understanding the universe that seems to us to be essential for all citizens of the future.

[1]Michigan Department of Education, *The Common Goals of Michigan Education*, September, 1971
[2]Obourn, Ellsworth S., *Science as a Way of Life*, U.S. Department of Health, Education and Welfare, April 1961

SCIENCE 1-3

PERFORMANCE OBJECTIVES

Identifying

1. By the end of the third grade, the learner will determine physical properties of simple objects (e.g., texture, shape, size, density, etc.), as measured by minimum criteria on an objectives-referenced test (ORT)

   1.1 The learner will describe verbally a given object (or picture of an object) by naming at least four or more physical properties of the object.

   1.2 Given a simple object the learner will determine at least four physical properties by manipulation without visual aid.

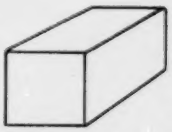
2. By the end of the third grade, the learner will identify two and three dimensional objects in terms of two or more properties, as measured by minimum criteria on an ORT.

   2.1 Given a set of two and three dimensional objects (or pictures of objects) which contain two or more physical properties, the learner will select the object(s) exhibiting specific properties from the set.

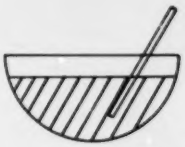
EXAMPLES AND COMMENTS

NOTE: This column contains sets of illustrations of the type of items which could be related to the assessment of a performance objective. A fourth column (the delivery system) should be developed by teachers (see p. v). Concepts in the delivery system should include health, biology, environmental education and the physical sciences.

1.1 Possible responses:



The object is blue
The object is solid.
The object is rectangular (or cubical).
The object is smooth.
Etc.



The Object is red.
The object is liquid.
The object has no shape.
The object is hot.
Etc.

1.2 Given a rubber ball, the learner will describe at least four of the properties.

Possible responses:

Shape - round
Density - light
Elasticity - squeezable - bouncy
Size - smaller than my hand
Temperature - cool
Texture - smooth
Hardness
Etc.

2.1 Find the round, hard, object.

PERFORMANCE OBJECTIVES

2.2 Given a set of two and three dimensional objects (5 or more) that vary in property, the learner will select all object(s) with a specified common property.

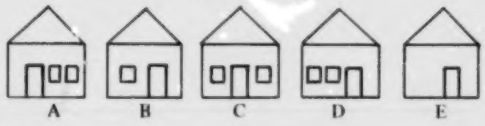
2.3 Given a set of two and three dimensional objects (10 or more) of several shapes (e.g., triangle, square, circle, ellipse, rectangle, prism, cube, sphere, etc.), the learner will select all objects of a specified shape.

3. By the end of the third grade, the learner will distinguish objects from one another on the basis of physical properties, as measured by minimum criteria on an ORT.

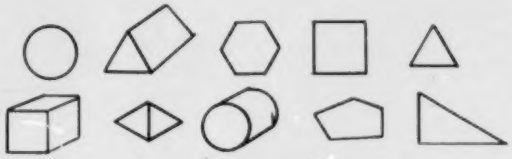
3.1 Given a set of objects (or a picture of a set) exhibiting a common property, the learner will select the object which exhibits the property to the greatest (least) extent.

EXAMPLES AND COMMENTS

2.2
Which houses have two windows and a door visible?_____

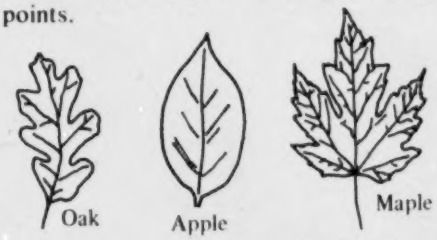


2.3
a. Find all the triangles.
b. Find all the four-sided shapes.

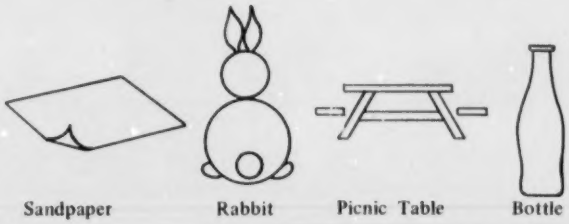


3.1a Circle the shortest stick.

3.1b. Put a mark over the leaf with the greatest number of points.



3.1c. Circle the picture of the object that is the softest.



SCIENCE 1-3

PERFORMANCE OBJECTIVES

4. By the end of the third grade, learners will distinguish between objects or sets of objects on the basis of quantity, as measured by minimum criteria on an ORT.

   4.1 Given sets of objects that vary in *number*, the learner will select the set that is numerically *larger than* or *smaller than* another.

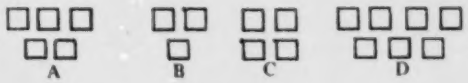
5. By the end of the third grade, the learner will classify objects characterized by specific properties, as measured by minimum criteria on an ORT.

   5.1 Given a collection of objects and/or organisms containing varying properties (e.g., color, size, temperature, etc.,) the learner will sort (classify) the objects into two sets of the basis of a common property.

   5.2 Given two classified sets of objects and organisms, the learner will identify a property which is common to only one set.

EXAMPLES AND COMMENTS

4.1a. Mark the letter of the set which shows the greater number.



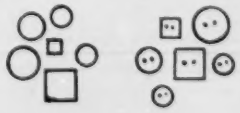
4.1b. Circle the letter under the creature which has the most legs.

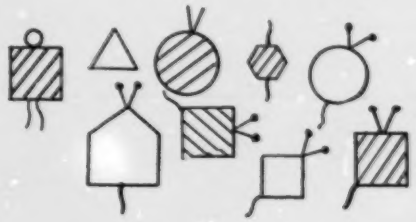
A Spider | B Ant | C Rabbit

5.1a Give the student an assortment of buttons. Have him divide them into two sets based on a common property of his choice (e.g., number of holes, color, size, shape, etc.).

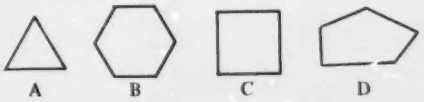
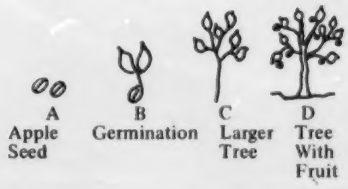
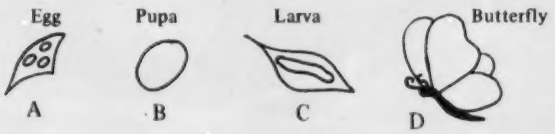
5.1b. Select one property of the organisms and draw a circle around all of those which show the same property. What property did you use?

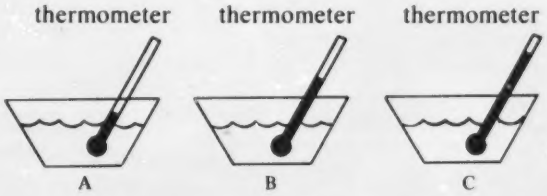
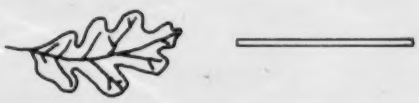
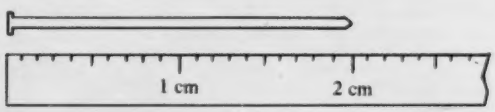
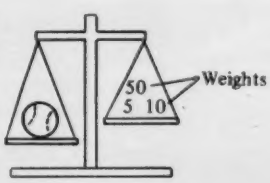
5.2a John sorted a pile of buttons into two piles. What property do you think he used?_____



PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
	5.2b. This is a Quirkee: Find all the Quirkees in this pond. 
5.3 Given a collection of objects and/or organisms, the learner will sort (classify) the items as living or non-living.	5.3 Place an N beside the objects which are non-living and an L beside those which are living. _____ rock _____ potted plant _____ frog _____ carrot _____ match _____ paper _____ insect _____ plastic toy
5.4 Given a collection of objects and/or organisms, the learner will sort (classify) the items as natural or manmade.	5.4 See above.
5.5 Given a collection of organisms, the learner will sort (classify) the organisms as plant or animal.	5.5 Place a *P* next to the organisms which are plants, and an *A* next to those which are animals. _____ horse _____ rose bush _____ ant _____ tree _____ potato _____ bird _____ toad _____ rotting stump
Sequencing	
1. By the end of the third grade, the learner will arrange objects or events in a prescribed sequence, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given a set of objects, the learner will arrange them in sequence according to weight.	1.1 Given five stones of varying weight, the learner will arrange them in the sequence according to *weight*, from *lightest* to *heaviest*.

SCIENCE 1-3

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
1.2 Given a set of objects, the learner will arrange them in sequence according to number.	1.2 Arrange the objects according to the number of *corners* they have, from the *smallest* number to the *largest* number.  (a) A B C D (c) D B A C (b) A C D B (d) C A B D
1.3 Given a set of living objects, the learner will arrange them in sequence according to development.	1.3a. Put these in order from earliest to latest growth.  (a) A B C D (c) A C B D (b) B D C A (d) A D C B
	1.2b. What is the order of growth (earliest to latest) ?  (a) A B C D (c) A C B D (b) D C B A (d) None of these.
Observing	
1. By the end of third grade, the learner will demonstrate the application of observational techniques, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given an object or picture which changes with successive observations, the learner will state at least one of the properties which is changing.	1.1 Have the learner taste a sample of unbaked cookie dough and a sample of a cookie made from the same dough. Ask the learner what changed in the baking. For example: hardness, texture, color, taste, smell.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
1.2 Given a thermometer and three or more containers of liquids, the learner will read the temperatures of the liquid using the thermometer.	1.2 Which of the jars is the coldest? Hottest? 
1.3 Given a magnifying glass and an object or organism with some characteristics not visable without a lens, the learner will observe the specimen with the lens and identify at least one of the characteristics.	1.3 Give the learner a small insect (such as an aphid, plant, lice, ant, etc.) and a magnifying glass and ask him how many legs the insect has.
Measuring 1. By the end of third grade, learners will be able to measure objects using standard measures, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given a standard unit of measure (inches, points, meters, grams, etc.), the learner will describe the object in terms of that standard unit.	1.1a The leaf is as long as_____ stick lengths?  1.1b The nail is_____ long  1.1c The weight of the ball is: a. More than 65 grams b. Less than 65 grams c. Exactly 65 grams d. Can't tell 

SCIENCE 1-3

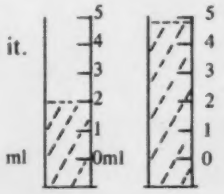
PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

1.1d These glasses have the same kind of markings on their sides.

Glass *2* has the most liquid in it.

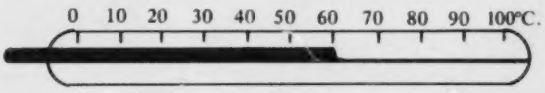
How much more liquid does glass 2 have ?



a. 5 ml
b. 3 ml
c. 2ml
d. 1ml

1.1e The best reading of this thermometer is _____ °C.

a. 50°C.
b. 52°C.
c. 60°C.
d. 61.5°C.



2. By the end of the third grade, the learner will devise a scheme for measuring an object or a condition, as measured by minimum criteria on an ORT.

2.1 Given an unmarked object as a standard, the learner will devise a method for determining the size of an object in relation to the standard.

2.1 Possible methods:

Given an unmarked stick (30 - 35 cm.) the learner could determine the length of a table (or other object over 1 meter long) to the nearest "stick."

With the same stick the student could then measure a small object (3-10 cm.) by marking the stick in equal divisions.

Inferring

1. By the end of the third grade, learner will discriminate between statements which are observations and those which are inferences, as measured by minimum criteria on an objectives-referenced test (ORT).

1.1 Given an observation situation, and sets of statements that are either observations or inferences, the learner will mark those that are inferences.

1.1 After pouring a liquid into a glass, the following statements can be made about the liquid:

a. The liquid is white.
b. The liquid is thicker than water.
c. The liquid is milk.
d. The carton has red letters.
e. The liquid tastes sweet.

Mark the above statement which is an inference.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
2. By the end of the third grade, the learner will construct inferences from sets of observations, as measured by minimum criteria on an ORT.	
2.1 Given a set of observations concerning an incident, object or a situation, the learner will make a valid inference concerning that incident, object or situation.	2.1 Observations: a. Two pans of liquid sit on a window sill. b. One pan is tightly covered with plastic wrap film. c. Both pans get the same amount of sunlight. d. The liquid in each pan tastes like water. e. The liquid in the uncovered pan disappears after 3 days. Which of these is a good inference to make concerning this situation? a. The plastic cover on one pan kept the liquid from disappearing. b. The water levels in the pan made the difference. c. Adding salt to a pan of water makes the water disappear faster. d. The pans are probably made of different materials.
3. By the end of third grade, the learner will distinguish between observations which support an inference and those which do not, as measured by minimum criteria on an ORT.	
3.1 Given an inference related to an observed incident, object or situation, the learner will select from a set of observations those that best support the inference.	3.1 Which observations would seem to best support the inference? Inference: The sun's heat on dark shingles on a roof causes snow on the roof to melt. Observations: a. There is snow on a garage roof. b. The roof is covered with black shingles. c. Two cars are parked in the garage. d. There is an outdoor, charcoal grill in the garage. e. The sun is shining in a cloudless sky. f. Shingles near the snow on the roof are wet. g. The garage doors are open.

SCIENCE 1-3

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

Processing Information

1. By the end of the third grade, the learner will process information into meaningful data (i.e., collect, organize, interpret, report, etc.) as measured by minimum criteria on an objectives-referenced test (ORT).

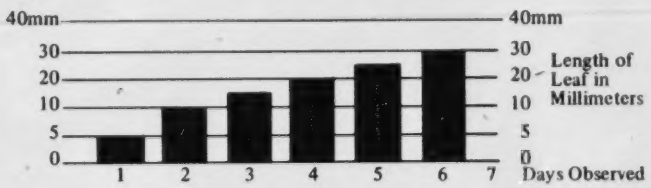
1.1 Given a bar graph with a variable which changes over time the learner can interpret the graph.

1.1 John read the water meter in his house each day for five days. Look at the following bar graph:

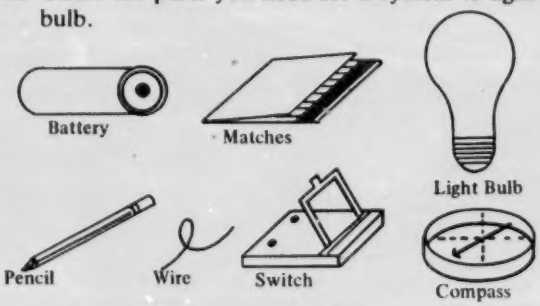
a. How many kilograms of water were used on day 4?
b. On which day was the least amount of water used?
c. On which day was 3½ kilograms of water used?

1.2 Given a bar graph with a variable which changes over time, the learner will interpret the graph, identify trends, and extropolate.

1.2 Look at the following graph:



a. How much did the length of the leaf change between the fourth and sixth day?
b. What would you expect the length to be on the seventh day?

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
1.3 Given a set of temperatures over a five day period, the learner will draw (or explain) a bar graph which indicates the change of temperature over time.	1.3 Construct a bar graph for the week's temperatures as given: Monday - 52° F Tuesday - 56° F Wednesday - 64° F Thursday - 66° F Friday - 65° F
1.4 Given a simple experiment in which a change takes place (physical, chemical, etc.), the learner will orally or in writing describe the objects used, events and changes.	1.4 Have the learner breathe through a straw into lime water and then describe what change(s) take place.
1.5 Given an elementary science experience, the learner will record observed information in simple, tabular form.	1.5 Here is information about a puppy: When he was born he was 3 cm. long and weighed 100 grams. When he was one week old he was 4 cm. long and weighed 130 grams. When he was one month old he was 6 cm. long and weighed 450 grams. Make a table to show how the puppy grew.
2. By the end of the third grade, the learner will identify relationships between phenomena (i.e., a system),as measured by minimum criteria on an ORT.	
2.1 Given a collection of objects and organisms, the learner can identify the set which exhibits a specific relationship.	2.1a Circle the parts you need for a system to light a bulb. 

SCIENCE 1-3

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
	2.1b The learner could be given a picture or group of pictures showing items which comprise both living and non-living systems. Ask the learner to point to the living system (i.e. aquarium, bird cage, books,etc.).
3. By the end of the third grade, the learner will identify the individual objects of a system (the parts) within a system (the whole), as measured by minimum criteria on an ORT.	
3.1 Given a system of objects and/or organisms, the learner can describe the relationship between the parts of the system.	3.1 Point to some system (or picture of a system) such as: An aquarium with fish and plants An electrical system with bulb, battery and wires An ecological area with plants, animals, soil. Ask the learner what relationship exists between part of the system.
4. By the end of the third grade, the learner will construct and test predictions from experimental data, as measured by minimum criteria on an ORT.	4.1a A boy found that when he placed four marbles of the same size in a can of water, the water would rise two centimeters. How high would the water rise, if the boy places only two marbles in the can of water? a. 0 centimeters b. 1 centimeter c. 2 centimeters d. 4 centimeters Show a sketch of the can of water.
	4.1b A little girl's pet turtle was moving toward a pond which was four meters away. In two minutes the turtle had traveled one full meter. After two minutes more, the turtle had traveled another full meter. The little girl who was watching her pet, said to her mother, "I think my turtle will reach the pond in _____. a. one more minute b. two more minutes c. three more minutes d. four more minutes Show sketch of turtle, pond, girl, and mother.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
4.2 Given a prediction based on observations, the learner will select from a list of activities those that would best confirm or negate the prediction.	4.2 A boy predicted that garlic has a smell (odor) most disliked by his classmates of all food materials used in cooking. In order to test his prediction, he should a. Ask his classmates to tell him what smell they dislike most. b. Test all the different materials himself. c. Make a list of the different materials used by his classmates' mothers and test his classmates with these materials. d. Ask the mothers of his classmates what smells their children dislike the most.

GRADES FOUR - SIX

Introduction

The world around the elementary school learner has many pulses and rhythms not visible and not felt in the written word, in the fractions and decimals of the domain of numbers and generally in the symbolism that pervades the learning activities of the traditional classroom. This militant symbolism is meaningless to the learner unless it is related to the real drama and clutter of the learner's various environments — and to the learner's immediate interests and needs.

Maturationally the sixth grade child is about one and one half years ahead of children of a generation ago. This means that puberty has arrived, or is very close. Thus, we have a child who needs more than ever to feel adequate and secure in an expanding aura of sensitivity, ignorance, and uncertainty. Perhaps this is the year when the child, the learner, will have the greatest need for feeling a part of things and for possessing a confidence that can come largely from knowing that one can cope with uncertainty.

Therefore, it should be our mission in science education to use science as a vehicle by means of which the eleven year old can feel increasingly that he has the means to find, make and use knowledge. To this end science education must provide the experiences which can develop the learner's competencies in the processes of science. These processes are really rubrics for the skills we need to cope with the unknown problems of each new day. These processes are observing, using space-time relationships, classifying, using numbers, measuring, communicating, predicting, inferring, controlling operationally, formulating models, and experimenting.

The sixth grade learner needs good science education because good science education (1) is an access route to reading, (2) has quantitative aspects which provide numerous and varied opportunities to use mathematics as a tool, (3) provides an important vehicle for teaching investigative techniques, and (4) enables children and youth to achieve a sense of control of their environment.

SCIENCE 4-6

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
Identifying and Classifying	NOTE: This column contains sets of illustrations of the type of items which could be related to the assessment of a performance objective. A fourth column (the delivery system) should be developed by teachers (see p. v). Concepts in the delivery system should include health, biology, environmental education and the physical sciences.
1. By the end of the sixth grade, the learner will construct an operational definition of living and non-living things, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given a set of living and non-living items, the learner will distinguish the living from the non-living.	1.1 Give the learner the following items (or pictures of these items): algae, mold, seed, plant, snail, fish, small mammal, wind up toy, stone cloth, nail. Then ask the learner to select or label the living/non-living items.
1.2 Given a set of properties and a set of living and non-living things, the learner will select those properties which apply only to living things.	1.2a Give the learner a collection of pictures of living and non-living things. Say to the learner: Mark with letter *A* those things in the picture which can grow, reproduce, and use food and water.
	Collection of Pictures ___ algae ___ wind ___ up toy ___ tree ___ hammer ___ kitten ___ chair ___ spider ___ newspaper
	1.2b Give the learner a picture of horses and automobiles. Say to the learner: Place an X after the words below which apply *only* to horses Can be made in a factory _____ Need food to survive _____ Can reproduce themselves _____ Never grow _____
1.3 Given several non-living items or materials, the learner will identify those having an origin associated with life.	1.3 From the following items the learner identifies those having an origin associated with life: coal — nail coral — bone fossil — granite or igneous rock cloth — plastic clam shell — glass

PERFORMANCE OBJECTIVES

2. By the end of the sixth grade, the learner will identify the structure of a green plant or of an animal in relation to its environmental survival, as measured by minimum criteria on an ORT.

2.1 Given three different living plants (including a typical annual and woody perennial), the learner will identify the leaves, stems, roots, and flowers.

2.2 The learner will give the basic function of leaves, stems, roots and flowers.

2.3 Given several small common animals, the learner will describe their gross structures.

2.4 Given a set of pictures of different animals in their regular habitats, the learner will identify those differences in structure among the animals which enable them to grow and survive in their proper environment.

EXAMPLES AND COMMENTS

2.1 & 2.2

Make available the following (or similar plants): green algae bean, small woody stemmed plant and carrot.

a. Ask the learner to label leaves, roots, etc., where present, including the location of chlorophyll.
b. Ask the learner to describe or choose a statement which describes the function of the above plant parts.

Note: The ability of algae to live without typical plant structures should be explained.

2.3 The learner could be given pictures of earthworms, fish, rats, butterflies, oysters, and cats. Ask the student to select pairs of pictures which contain an animal with a backbone and one without a backbone.

Collection of Pictures		
earthworms	fish	rat
cat	oyster	
butterfly		

a) earthworm - fish
b) earthworm - butterfly
c) rat - fish
d) cat - fish

Which pair of the following contains animals both of which breathe underwater?

a) earthworm - fish
b) earthworm - cat
c) fish - oyster
d) rat - cat

2.4 The learner could be given pictures of earthworms, fish, and rats and asked to respond to each of the following:

a. Earthworms live in the soil because they

(1) cannot breathe on land
(2) obtain their nourishment from the soil

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

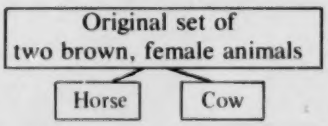
(3) have fins
(4) have a backbone

c. Rats do not live in water because they
(1) have legs
(2) do not have fins
(3) cannot remove the dissolved oxygen from water when they breathe
(4) have a backbone

3. By the end of the sixth grade, the learner will classify organisms into appropriate categories and sub-categories of an established dichotomous classification system, as measured by minimum criteria on an ORT.

3.1 Given a single stage dichotomous classification system containing one animal in a category different from another animal in another category, the learner will name at least one characteristic which could be accepted by the teacher as a basis for placing the two animals in categories.

3.1 In the diagram below decide which characteristic given is a good reason for placing each animal in a different box.



Which of the following characteristics would provide a good reason for separating the original set of animals into horses and cows?

(a) horses have four legs
(b) cows have split hooves
(c) cows are females
(d) horses eat grass

Note: Recommend sketches of the animals.

Observing

1. By the end of the sixth grade, the learner will describe rates of change observed in the environment, as measured by minimum criteria on an objectives- referenced test (ORT).

1.1 Given a set of observations regarding motion or growth of objects, the learner will describe differences in the rates of motion or growth.

1.1a On a certain sunny day in Michigan, the length of a tree's shadow changed from 12 meters to 10 meters in one hour. The rate at which the length of shadow changed is:

(1) 12 meters per hour
(2) 10 meters per hour
(3) 2 meters per hour
(4) 22 meters per hour

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

1.1b A container of water placed on a table in a classroom changed from a volume of 500 milliliters to 400 milliliters in one day. This means that water was lost at the rate of

(1) 50 milliliters per day
(2) 100 milliliters per day
(3) 400 milliliters per day
(4) 500 milliliters per day

1.1c One day a boy observed that an ant traveled a distance of one meter in 20 seconds, while an earthworm traveled the same distance in 40 seconds. Place an X after the words below which describe the difference in the speeds of the ant and the earthworm.

The ant was faster than the earthworm _____

The ant was slower than the earthworm _____

The ant traveled the same distance as the earthworm _____

or — more difficult sets of possible answers below:

The ant traveled the same distance as the earthworm _____

The earthworm traveled one meter in 20 seconds more time than the ant _____

The ant was slower than the earthworm _____

or

The ant traveled the same distance as the earthworm _____

The ant was two times faster than the earthworm _____

The ant was slower than the earthworm. _____

1.1d A child planted a seed and measured its growth in height at selected intervals. The following data (information) of plant growth were recorded:

Days after Planting	Height of Plant
4	1 cm.
6	5 cm.
7	10 cm
11	23 cm.
13	28 cm.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

During what interval of time did the plant change the most in height?

Between the 4th and 6th day_____

Between the 6th and 7th day_____

Between the 7th and 11th day_____

Between the 11th and 13th day_____

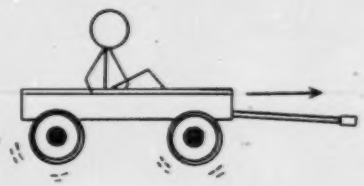
2. By the end of the sixth grade, the learner will describe changes in position and motion of objects relative to one's own position and to that of another observer, as measured by minimum criteria on an ORT.

2.1 Given a stationary object on a moving vehicle, the learner will describe the object's motion relative to the moving vehicle and to the earth.

2.1a A stick figure could be placed on a cart to depict the stationary object. Pull the cart along a pathway. While the cart is moving

(a) ask the learner whether the stick figure is moving relative to the cart. (The answer is no).

(b) ask the learner whether the stick figure is moving relative to the earth. (The answer is yes)



2.2 Given a situation in which he is a stationary observer in a moving vehicle, the learner will describe his own motion relative to other objects.

2.2 John and Mary are in the front seat of a car traveling down an interstate highway at 70 miles per hour. Describe John's position in relation to (1) the car; (2) Mary and (3) a highway worker that the car is (a) approaching; (b) passing and (c) has passed on John's side of the road.

2.3 Given a simulated situation in which the learner is on the side of a road along which a vehicle proceeds carrying a stationary cargo, the learner will describe the motion of the cargo relative to the learner and relative to the moving vehicle.

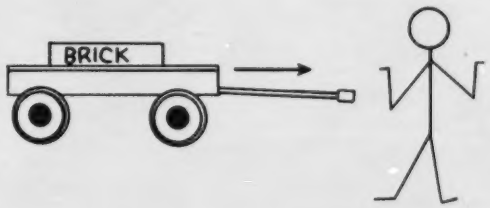
2.3a Pull a cart carrying a brick in front of the learner. While the cart is moving:

(1) ask the student whether the brick is moving relative to the learner. (The answer is yes).

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

(2) ask the learner whether the brick is moving relative to the cart. (The answer is no).



2.3b John is traveling along an Interstate Highway at 70 miles per hour in a car which he is driving. Mary is standing at the side of the road on the driver's side of the car. Describe John's position in relation to (1) the car and (2) Mary. Tell (a) how Mary would describe the car and John and (b) how John would describe the car and Mary. Then (c) give your own description of John's motion (1) relative to the car and (2) relative to Mary. Use as many of the terms as you can indicate in the question above.

2.4 Given a car that is traveling faster than a second car and in the same direction, the learner will determine how fast either car is traveling relative to the other.

2.4a A car driven at 50 miles per hour is being followed by another car driven at 60 miles per hour. Determine the speed of the faster car relative to the slower car.

(a) 60 miles per hour
(b) 0 miles per hour
(c) 50 miles per hour
(d) 10 miles per hour

2.4b John is driving down an Interstate Highway at 60 miles per hour. Mary is driving a car of the same kind down the same highway in the same direction at 70 miles per hour. Mary sees John ahead of her. (1) Describe how John's car looks to Mary as she approaches and passes it and (2) assuming that John is 10 miles ahead of Mary when she first sees him, tell how many miles it will take her to catch up with him and pass him. (3) How long will it take her (in terms of time)? Use such terms as ahead, approach, near, far, away, behind.

SCIENCE 4-6

PERFORMANCE OBJECTIVES

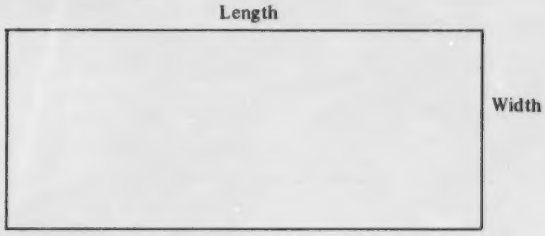
EXAMPLES AND COMMENTS

Measuring

1. By the end of the sixth grade, the learner will measure in metric units according to the precision and accuracy of the measuring instruments provided, as measured by minimum criteria on an objectives-referenced test (ORT).

1.1 Given a metric ruler or metric stick, the learner will determine the dimensions of measurable objects to the nearest centimeter.

1.1 Measure the length and width of the rectangle shown below:



Which length is correct?	Which width is correct?
(a) 4.0 cm.	(a) 1.0 cm.
(b) 5.0 cm.	(b) 5.0 cm.
(c) 7.0 cm.	(c) 3.0 cm.
(d) 1.0 cm.	(d) 4.0 cm.

Note to testmaker: The rectangle should be drawn such that its dimensions are not in whole numbers of centimeters.

1.2 Given a graduated cylinder, the learner will distinguish between various volumes of the same liquid and describe the differences in terms of the measure provided.

1.2 On the work counter are two containers of water and a cylinder calibrated in millimeters. Determine the difference in volumes between the two containers.

The difference is nearest:
(a) 20 ml.
(b) 25 ml.
(c) 30 ml.
(d) 40 ml.

1.3 Given an equal-arm balance (homemade or otherwise) and an object of unknown mass, the learner will determine the number of arbitrary units (paper clips, tacks, etc.) it takes to balance the unknown mass.

1.3 On the work counter is a pebble, an equal-arm balance and a box of paper clips. Determine the mass of the pebble in paper clips to the nearest whole paper clip.

Note to examiner: Allow an error of $\pm 10\%$ of the accepted answer. For example, a mass weighing 100 paper clips could be recorded by the student as having a mass of 90 or 100 paper clips.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

Processing Information

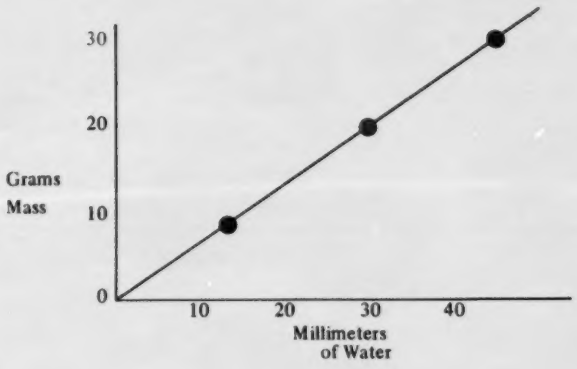
1. By the end of the sixth grade, the learner will process data into meaningful information (i.e., collect, interpret, hypothesize, report, etc.), as measured by minimum criteria on an objectives-referenced test (ORT).

   1.1 Given a completed graph of plant height versus growing time, the learner will predict from the graph the time required to attain a given height in time units specified on the graph.

   1.1 A completed graph should appear on the test paper. Then give the learner a plant height as described in the performance objective and ask the learner to read from the graph the time in specified units required for the plant to reach the given height. This could be reversed, that is, give the learner a time between two plotted times and ask him to predict the plant height at the given time.

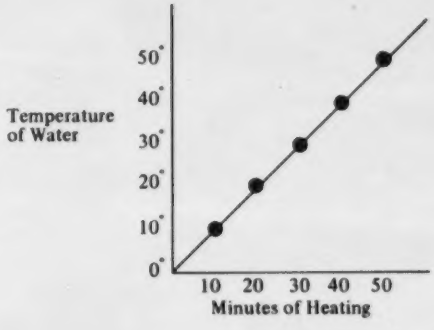
   1.2 Given a completed bar (or line) graph of mass of water versus volume of water, and given a volume greater than any plotted on the graph, the learner will determine from the graph the mass of water corresponding to the given volume.

   1.2 From the graph below, what is the mass of a volume of water of 40 millimeters?



   1.3 Given a completed line graph of water temperature versus time in a heating range of 0° celsius, and given a temperature between two plotted times, the learner will predict from the graph the temperature required to achieve the given time.

   1.3 From the graph below what is the temperature of water at the end of 35 minutes?



PERFORMANCE OBJECTIVES

1.4 Given a completed line graph of the length of a spring versus a mass suspended from the spring, and given a mass greater than any mass predicted in the graph, the learner will determine from the graph the spring length corresponding to the given mass.

2. By the end of the sixth grade, the learner will distinguish between inferences that account for all stated observations and those which do not, as measured by minimum criteria on an ORT.

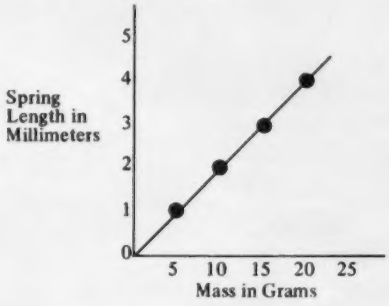
2.1 Given a set of observations and inferences pertaining to an event, the learner will select those inferences which account for the observations.

3. By the end of the sixth grade, the learner will design an investigation to test an inference, as measured by minimum criteria on an ORT.

3.1 Given an inference(s) which can be tested in the classroom, the learner will identify at least one way the inference can be tested by himself or others.

EXAMPLES AND COMMENTS

1.4 From the graph below what is the spring length for 25 grams of mass?



2.1 During the fall of the school year, an elementary school boy observed that whenever he and his friends began to play ball on a street in their neighborhood, there was an increase in car traffic. He noticed that the car traffic increased began at 4:00 p.m. The boy remembered that this did not happen during summer months. The boy new, also, that the high school on the street dismissed at 3:45 p.m.

Select from the following the inference that accounts for the boy's observations:

(a) people who own cars do not want boys to play ball.
(b) the traffic was caused by the teachers and students from the high school.
(c) people like to shop after 4:00 p.m.
(d) the best time to drive is at 4:00 p.m.

3.1 Using the following inferences, the learner will select the most scientific procedure for testing it. He may choose more than one procedure, but he must indicate which procedure he would use first, second, etc.

(1) Inference:
(a) seeds need soil to germinate and grow

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

Investigations:

(1) Five seeds are placed in dry soil, five on a wet blotter paper in a jar and five seeds from the same package are placed in moist soil and kept at room temperature.

(2) Five seeds are placed in dry soil and five on moist soil. Both are kept at room temperature.

(3) Five seeds are placed in dry soil, five in an empty jar and five are placed on a dry piece of paper at room temperature.

(4) Five seeds are placed in water.

(5) One seed is placed in an empty jar and observed for five days.

(2) Inference:

(b) plants need light in order to live.

Investigations:

(1) A plant is placed in a refrigerator to keep it dark.

(2) One plant is kept in the window and one plant is kept in a closet.

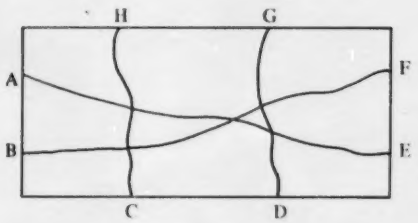
(3) One plant is kept near a window and one in a closet. Both are watered equally and observations and measurements made three times a week for one month.

4. By the end of the sixth grade, the learner will construct models that might account for unobservable objects of phenomena, as measured by minimum criteria on an ORT.

4.1 Given a "black box" (or hidden electrical circuits) the learner will describe or sketch the shape or arrangement that could account for observations.

4.1a Given a sealed shoe box containing a marble and a pencil, the student should determine the number and relative differences of the objects.

4.1b Using a hidden circuit board or box (such as below), the learner will sketch the arrangements of wires by testing electrical connections. (This example is not a minimal one).



PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
4.2 Given a series of astronomical observations, the learner will arrange objects (styrofoam balls, lights, etc.) to simulate these observations.	4.2 Give the learner small and large styrofoam balls and a flashlight, ask the learner to arrange them to account for pictures of moon phases.
5. By the end of the sixth grade, the learner will identify the controllable and non-controllable variables of a system, as measured by minimum criteria on an ORT.	
5.1 Given a system which can be replicated, the learner will distinguish between the controllable and non-controllable variables.	5.1 A learner wishes to determine the effect of different volumes of water on the melting time of an ice cube. Place a "C" after the variable(s) which the learner can control and an "N" after the variable(s) which the learner cannot control. (a) temperature of the water at start (b) size of the ice cubes (c) volume of the water (d) the weather
5.2 Given a hypothesis and a description of an investigation to test the hypothesis, the learner can specify the control necessary to complete the investigation.	5.2 A learner constructed a hypothesis that *vegetables contain water*. In order to test his hypothesis, he decided to heat a piece of *different* vegetable in each of five test tubes. The five vegetables he selected were lettuce, carrots, string beans, turnips, and spinach. After heating each test tube and contents, he observed droplets of a liquid along the sides of the test tube. The learner applied a test for water to these droplets and the test proved that the droplets were water. After discussing the investigation with his teacher, the learner agreed he should add a *control*. Select from the following the control the student should use: The learner should have (a) a test tube containing water (b) a test tube containing meat (c) an empty test tube (d) a test tube containing fish

GRADES SEVEN - NINE

Introduction

The objectives in elementary school science have gradually changed in emphasis from process in the early elementary levels to content in the later elementary levels. By the end of the sixth grade each learner should have developed a set of fundamental skills and progressed along with a gradually increasing level of challenging content.

By the end of the ninth grade each learner is expected to have mastered, as a minimum requirement, certain basic concepts in various areas of science. But just as important as the mastery of basic science concepts, the learner is expected to become aware of his surroundings in order to develop a value system which would enhance his life style. In other words, there is a gradual shift in emphasis, for the ninth level objectives, from the cognitive domain toward the integration of the cognitive with the affective.

Never before in the history of mankind has there been a greater need for all segments of society to become active participants in resolving issues in the environment, technology, population and countless other areas. For many students the ninth grade may be their last exposure to any formal training in science. Yet in the years ahead these students will be confronted with issues that will have far reaching effects on their lives. They will be asked to vote on certain issues, participate in national and community concerns and even obtain vocations, in some cases, which will deal with the problems of the environment and technology. Therefore the ninth level objectives were constructed to reflect a growing concern for the issues of science, technology and society and their interrelationships.

PERFORMANCE OBJECTIVES

Observing

1. By the end of the ninth grade, the learner will select observations appropriate to a specific task, as measured by minimum criteria on an objectives-referenced test (ORT).

   1.1 Given a task involving observation, the learner will select those observations that best allow the task to be performed.

EXAMPLES AND COMMENTS

NOTE: This column contains sets of illustrations of the type of items which could be related to the assessment of a performance objective. A fourth column (the delivery system) should be developed by teachers (see p. v). Concepts in the delivery system should include health, biology, environmental education and the physical sciences.

1.1a A learner was asked to determine the mass of table salt that would dissolve in 1,000 ml of water when the water temperature is at 25°C. at the start of the investigation. During the investigation the learner made the following observations:

(1) Water temperature at start was 25°C.
(2) The solution had no odor.
(3) After dissolving 390 grams of salt, no more salt would dissolve.
(4) The temperature outside the classroom was 18°C.

Which of the above observations would be least helpful?

(a) 1,2
(b) 2,4
(c) 1,3
(d) 2,3

1.1b Given a tray of 10 corn seedlings and the task of determining the rate of growth of the plants, which one of the following observations are *most* useful?

(1) The pan is 11" x 15" x 1".
(2) The measurement in millimeters in diameter of the seedlings.
(3) The pan is painted gray.
(4) The corn seedlings are green.
(5) The height of the seedlings.
(6) The plants have been kept in a controlled humidity chamber.

1.1c Given an enclosed metal can with a number 1 cork having a short piece of glass sticking out from it, the learner will determine the contents of the can by:

1. Shaking the can.
2. Smelling the can.
3. Rolling the can along a smooth surface.

PERFORMANCE OBJECTIVES

Environmental Education

1. By the end of the ninth grade, the learner will identify relationships between science, technology, the natural world, and society, as measured by minimum criteria on an objectives-referenced test (ORT).

EXAMPLES AND COMMENTS

4. Weighing a similar empty can and comparing its mass to that of the unknown can and its contents.

Which observation is the *least* helpful?
a. 1,2
b. 2,3
c. 1,4

Which observation is the *most* helpful?
a. 1,2
b. 2,3
c. 1,4

1.1a The world is moving rapidly toward an energy deficit, that is a situation in which the energy requirements will exceed the foreseeable available energy. The construction of nuclear reactor is one way in which science and technology are trying to prevent an energy crisis. Which one of the following relationships applies the most accurately to the problem just described:

(1) The question of building nuclear reactors is the responsibility of science, technology, and society acting together.
(2) Society has no right to decide whether nuclear reactors are built.
(3) Society should stop using electrical appliances.

1.1b The hydrologic cycle is pictured below. After looking at the picture (or other observation), select the correct statement.

(1) When it rains it is observed that some water soaks into the ground and raises the level of the water table.
(2) Plant leaves burst after a heavy rain because they become swollen in the rain water.
(3) Plants die after a heavy rain because all the nutrients are washed out of the soil.
(4) River raises after a period of heavy rainfall.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

1.1c In the forest edge community there are many fruit-eating birds. There are also many fruit-bearing trees, shrubs, vines and broad-leaved herbaceous plants.

(1) The leafy plants attract the birds and cause them to build nests there.
(2) The birds are able to hide from their enemies in the vegetation.
(3) The birds eat the fruit, pass the seed through their digestive tracts, and deposit the seeds on the ground where they can grow and become a part of the forest edge.
(4) Birds live in the forest edge community because man feeds them there.
(5) Some kinds of birds are attracted to man, and may be a forest edge animal in his ecological relationships.

1.1d After it rains you notice the next morning that mushrooms have grown on the lawns of a few houses in your neighborhood. Select the correct statement below:

(1) The rain has small mushroom plants within its drops.
(2) Rainy weather always makes mushrooms grow.
(3) A combination of rain and darkness may cause mushrooms to grow.

2. By the end of the ninth grade, the learner will identify problems in science that need solutions, as measured by minimum criteria on an ORT.

2.1 Given a set of issues or problems, the learner will identify those with which science is currently dealing.

2.1 The following are some of the issues which currently are facing our society.

(1) Provision of an adequate source of energy.
(2) Understanding the origin of the universe.
(3) Controlling population of air, water, and soil.
(4) Defining the nature of God.
(5) Provision of adequate housing.
(6) Elimination of slum conditions in our central cities.
(7) Elimination of war as a means of settling human problems.
(8) Devising a relatively pollution-free engine.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

Mark the *pair* of issues below in which *both* issues are currently being dealt with by science.

1 and 3

2 and 6

3 and 4

6 and 7

5 and 8

2.2 Given an issue or problem in science that is being solved, the learner will identify new problems resulting from its solution.

2.2 It appears now that solution of the problem of pollution is being accomplished, but that it will be very costly. Which of the following problems will be a probable result of the solution of the pollution problem:

a. An increase in the population of some insects that are crop pests or disease carriers.
b. An increase in the amount of automobile traffic on our highways.
c. An increase in human population.
d. An abandonment of some currently productive avenues of scientific research.
e. Permanent changes in the world's weather.

Controlling Variables

1. By the end of the ninth grade the learner will identify controls and variables pertinent to an investigation, as measured by minimum criteria on an objectives-referenced test (ORT).

1.1 Given pertinent information concerning an investigation the learner will identify at least one control and one variable.

1.1a In the 17th Century it was a popular belief that meat turns into maggots when not covered. A scientist set up an experiment in the following manner to test this belief. (All jars contained meat):

Jar A was left open to the air.

Jar B was covered by glass.

Jar C was covered by screen.

(1) Select the jar or jars which represent the variable
(2) Select the jar or jars which represents the control.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

1.1b You are growing some corn seeds in three different pots. The first pot is placed in darkness. The second is placed on a counter top in the room, and the third is placed in a dark closet.

1. Select the jar or jars that represent the variable
2. Select the jar or jars that are the control(s).

Processing Information

1. By the end of the ninth grade, the learner will recognize the difference between facts, concepts, inferences, theories and hypotheses, as measured by minimum criteria on an objectives referenced test (ORT).

1.1 Given a fact, an inference, a concept, a theory and a hypothesis applicable to a certain situation or event, the learner will differentiate between at least two of them.

1.1 The light is on. (fact)
The bulb appears to be hot. (inference)
Electrical energy may be converted to light energy. (concept)
Electricity can produce light in a bulb. (hypothesis)
Electricity flows through conduction. (theory)

After reading the following statement, select the best answer.

Because the electric light is on, the light bulb appears to be hot.

1. The inference is a natural follow-up of the fact.
2. The fact is no way the cause of the inference.
3. The statement is based on a hypothesis.
4. The statement is based on a theory.

2. By the end of the ninth grade, the learner will distinguish between scientific evidence and opinion, as measured by minimum criteria on an ORT.

2.1 Given one set of statements indicative of scientific evidence and one set of statements indicative of opinion, the learner will identify at least one difference between scientific evidence and opinion.

2.1 There are statements which are based on opinions. There are statements which are based on scientific evidence. From the following list of statements, select the one which is not an opinion.

1. Wearing heavy clothing in the winter prevents colds.
2. Only planet earth can support life.
3. Science can solve all of the problems of mankind.
4. The world is round.

PERFORMANCE OBJECTIVES

3. By the end of the ninth grade, the learner will distinguish between relevant and irrelevant data of an investigation, as measured by minimum criteria on an ORT.

   3.1 Given data contained in an investigation, the learner will identify at least one difference between those data which are relevant to the investigation and those which are not relevant.

4. By the end of the ninth grade, the learner will interpret and make generalizations from new data, as measured by minimum criteria on an ORT.

   4.1 Given data about two or more variables, the learner will construct a graph or table describing the relationship between the variables.

EXAMPLES AND COMMENTS

3.1a A group of ten brown male mice were fed potato chips and pop. A group of ten white mice were fed a balanced mouse diet. From the following list identify one datum relevant to the investigation.

1. number of mice
2. color of mice
3. kind of diet
4. sex of mice

3.1b If you are driving a car, alone, lost and in a rural area away from marked or paved highways, and you come to a road intersection, which of the following is most likely to influence the alternative road you choose.

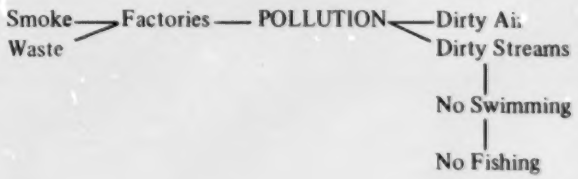
1. The direction of the road.
2. The cloudiness of the day.
3. The question of whether or not it is raining.
4. The extent to which the road is traveled.
5. The vegetation growing on the roadsides.

4.1 From the following data, construct a graph of the speed of a car traveling along a highway.

Time in Minutes	Distance in Miles
0	0
5	3
10	6
15	9
20	12
25	15
30	18

Velocity (speed) = Distance x Time

What is the speed of the car in miles per hour (not in minutes)? _____

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
4.2 Given a problem, the learner will *identify* the cause and effect relationships of the problem.	4.2 Our age is suffering from a problem of pollution. Which of the following human activities is/are a cause(s) of pollution? a. Driving an automobile. b. Using an insecticide on your vegetable garden. c. Dumping sewage from a city in a lake or stream. d. Building a new house. e. Discharging smoke from a foundry into the air.
4.3 Given a problem, the learner will *describe* the cause and effect relationships of the problem.	4.3 The learner describes first the cause chains of pollution and second the effected chains (i.e., What causes pollution and what are its effects?) 
5. By the end of the ninth grade, the learner will carry out an investigation resulting in a hypothesis obtained from the data, as measured by minimum criteria on an ORT.	
5.1 Given a collection of data obtained through the learner's investigation, he will be able to construct a hypothesis.	5.1a The learner is about to invest in a used car. The choice has come down to three cars: (1) Car A is a make and model rated highly in *Consumer Reports*, but is five years old and has 55,000 miles on it. (2) Car B is an "offhand" foreign car that was bought new by a friend who recommends it highly, but has to sell it because he needs the money. It has only 10,000 miles on it and has never been in for repairs. (3) Car C is a standard make and is only a year old. It has only 20,000 miles on it but has been rebuilt following a major accident. The prices of all three cars are the same. The learner's proposed action (equivalent to a hypothesis) is: (a) I will buy Car A because— (b) I will buy Car B because — (c) I will buy Car C because —

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

5.1b Compare barometer readings and weather forecasts for about three weeks. Form a hypothesis about the barometer pressure changes as a forecast for weather changes.

5.1c Using a 2" x 2" x 8" block of wood that has one smooth face and one edge that has a screw eye in the center connected to a spring scale, drag the block across samples of wood, cork, rubber, sand paper, etc., and record the force required for each trial. Which property (color, smoothness, etc.) has the greatest force of friction? What hypothesis can be made from this experiment?

6. By the end of the ninth grade, the learner will design and conduct an experiment testing a hypothesis, as measured by minimum criteria on an ORT.

6.1 Given a hypothesis, the learner will design and conduct an experiment which will test the hypothesis.

6.1a During an investigation of seed germination, a learner proposed the hypothesis: Corn exposed to freezing temperatures will not germinate. Determine the best sequence of steps that the student should follow to design and conduct an experiment to test the above hypothesis from the following:

(1) Interpret data
(2) Determine controllable and non-controllable variables
(3) Make observations
(4) Modify hypothesis if necessary

The best sequence is:

(a) 2,3,1,4
(b) 1,2,3,4
(c) 2,3,4,1
(d) 4,3,2,1

6.1b Given the hypothesis: Any acid can be recognized by the following characteristics:

(1) Turns blue litmus paper red (pink)
(2) Turns phenolphthalein colorless
(3) Makes limestone "fizz"

Give the learner an assortment of red and blue litmus paper, vinegar, some weak base, phenolpthalein, granite, limestone, etc., to determine which liquid (vinegar, weak ammonia, etc.) is the acid. Using the above hypothesis, have the student identify any material that is an acid.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

6.1c Given the hypothesis: The strength of an electromagnet increases with the number of turns of the coil surrounding the core:

(1) The first student used a large nail, an ammeter, and a coil of insulated No. 20 wire and several batteries. The strength of the magnet was determined by the number of paper clips that were picked up using 5, 10, 20, 40 turns.
(2) Another student did not use an ammeter to maintain a constant current.
(3) A third student used 1, 2, 3, 4 and 5 turns of wire with each test of strength.
(4) Another student tested the strength of the magnet by seeing how hard it pulled on a screwdriver.

Which method is the best for testing the hypothesis?

6.1d Given a hypothesis: Water exposed to different environments contain various amounts of solids and materials. A learner should be able to set up an experiment to prove this.

For example, the learner could set up a number of evaporation dishes containing a given amount of water from various environments such as rain water, tap water, stream water, lake water, sewage and water from other local sources. Evaporate the water in each case and observe and measure the amount of solids remaining in each dish.

7. By the end of the ninth grade, the learner will construct a model for an object or a phenomenon based on observational evidence (five senses) which provides a possible explanation for it, as measured by minimum criteria on an ORT.

7.1 Given a set of observations obtained by manipulation of a system, the learner will construct a model which will explain the behavior of the system.

7.1a Using a box with a small object inside which he cannot see or touch, the learner should test the object using all senses possible. The learner should construct a model of the object on the basis of his manipulation and observations (size, shape, etc.)

7.1b It is observed that small quantities of sugar can be added to water and when it has dissolved the volume of water remains about the same. Other soluable material also does not increase the volume perceptibly. Which of the following models of water best accounts for the observation:

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

(1) Sugar particles go into water particles which are hollow.
(2) Sugar particles are hollow and take in some of the water particles.
(3) There are spaces between water particles into which sugar particles can fit.
(4) Sugar particles are so small they have no volume (take up no space).

Select the hypothesis that is *least* plausible.

8. By the end of the ninth grade, the learner will construct line graphs from sets of number pairs obtained from measurements, as measured by minimum criteria on an ORT.

8.1 Given a set of measurements of plant height in metric units and a series of constant time intervals during which plant height changed, the learner can construct a line graph of height versus time. The completed graph should show:

(1) The vertical axis labeled *height in metric units*
(2) The horizontal axis labeled *time* (in appropriate intervals)
(3) A smooth curve connecting the plotted points.

8.1 A scientist performed an investigation during which he tried to find out how a plant changed in height over a period of six weeks. The data he collected are listed in the table below. Construct a line graph of the data.

Height of Plant (centimeters)	Height of Plant Measured at end of:
1.3	1 week
4.9	2 weeks
11.0	3 weeks
20.0	4 weeks
31.0	5 weeks
44.0	6 weeks

8.2 Given a set of measurements of pendulum swings per unit time and associated pendulum lengths in metric units, the learner can construct a line graph of pendulum swings per unit time versus length of pendulum. The completed graph should show:

(1) The origin labeled *(0.0)*
(2) The vertical axis labeled *number of swings per unit time*
(3) The horizontal axis labeled *length of pendulum* (in metric units
(4) A smooth curve connecting the plotted points

8.2 A student used several different lengths of string and a weight to make pendulums each of which he caused to swing back and forth in order to count their swings per minute. Following is a table of information which he gathered during his study of pendulums. Construct a line graph of the data.

Number of swings in one minute	Length of pendulum in cm.
46	50
36	70
29	110
24	150
21	180
18	230

PERFORMANCE OBJECTIVES

8.3 Given a set of measurements of flow of a liquid into a graduated cylinder, the learner will construct a line graph of the volume of liquid in metric units versus time. The graph should show:
(1) The origin labeled *(0.0)*
(2) The vertical axis labeled *volume* (in metric units)
(3) The horizontal axis labeled *time* (in appropriate intervals)
(4) A smooth curve connecting the plotted points

8.4 Given a set of measurements of the length of a material which stretches to different lengths when different masses are suspended from the material, the learner will construct a line graph of length of stretchable material in metric units versus mass. The graph should show:
(1) The first point as 0, (original length)
(2) The vertical axis labeled *length of material*
(3) The horizontal axis labeled *mass* (in appropriate units)
(4) A smooth curve connecting the plotted points

Measuring

1. By the end of the ninth grade, the learner will select appropriate instruments and/or tools for the purpose of measuring, as measured by minimum criteria on an objectives-referenced test (ORT).

EXAMPLES AND COMMENTS

8.3 A student made a pinhole in a paper cup filled with water and measured the flow of water into a graduated cylinder. He made observations of the water filling the cylinder and the time it took to get to each level. Construct a line graph of the information he gathered. This information or data is in the table below.

Volume of water in milliliters (ml)	Time in seconds
0	0
10	20
15	40
22	60
28	80
32	100
40	120
42	140
50	180

8.4 A student held one end of a rubber band in his hand while another student attached objects of different weights and sizes (mass) on the other end of the rubber band so that he could measure the stretch. Construct a line or bar graph of the measurements made by the second student. The measurements are given below:

Length of rubber band in cm.	Masses in grams
9	0
13	100
22	200
31	300
39	400
45	500
49	600
52	700

PERFORMANCE OBJECTIVES

1.1 Given a task involving measuring and a set of measuring instruments or tools, the learner will select the instrument or tool appropriate to the task.

2. By the end of the ninth grade, the learner will recognize and/or construct instruments and/or tools for the purpose of measuring, as measured by minimum criteria on an ORT.

2.1 Given a task involving measuring the learner will construct from available materials a suitable instrument or tool.

3. By the end of the ninth grade the learner will utilize scientific instruments for measurement with accuracy consistent with the instrument used, as measured by minimum criteria on an ORT.

3.1 Given an instrument and a task, the learner will measure accurately.

EXAMPLES AND COMMENTS

1.1 Determine the volume and weight of a carton of sand. Given the following instruments, indicate the one you would use to measure:

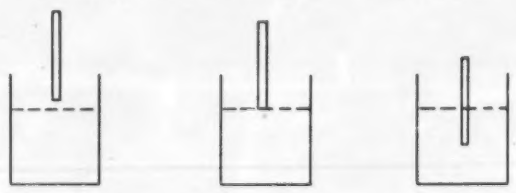
(a) *Volume*
1. balance
2. stick
3. microscope
4. graduated cylinder

(b) *Weight*
1. balance
2. meter stick
3. microscope
4. graduated cylinder

2.1 In order to determine the weight of a wooden block, which of the following sets of materials would you use to build an instrument to accomplish this task?

(1) yardstick, tin cans, string, set of weights
(2) yardstick, microscope, hammer
(3) stand, beaker, bunson burner
(4) yardstick, saw, nails, hammer

3.1a Given three jars with liquid and thermometers placed in them as shown below, which of the following will give the most accurate reading of the temperature of the liquid in the bottle?



(1) A
(2) B
(3) C

3.1b Which unit of measurement on the meter stick would you use to accurately measure a tennis court?

(1) millimeter
(2) meter
(3) centimeter
(4) decimeter

SCIENCE 7-9

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
Potentials & Limitations of Science	
1. By the end of the ninth grade, the learner will recognize the limitations of science, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given a set of contemporary problems, the learner will select those which are not likely to be solved by science this year.	1.1 The following are problems which are common to all nations. From the list select one which may possibly be solved by science this year. (1) flu vaccine (2) population growth (3) poverty (4) depletion of natural resources (5) a cheap way of desalting water
1.2 Given a set of problems, the learner will predict the order in which they are likely to be solved.	1.2 List the order in which the following problems might possibly be solved: (1) Landing a man on Mars (2) Successful brain transplants (3) Develop a machine to travel backward in time Predict order: (a) 2,1,3 (b) 1,2,3 (c) 3,2,1
2. By the end of the ninth grade, the learner will demonstrate awareness that scientific knowledge has developed in an evolutionary manner and historically has been limited by man's contemporary capabilities, as measured by minimum criteria on an ORT.	
2.1 Given an event in history, the learner will select one of the five factors which would be most likely to produce changes.	2.1 Man had the scientific capability to voyage to the moon in the 1930's but the trip was not made until the late 1960's. Choose the best reason for the delay: (1) Lack of technological capability. (2) Einstein had not developed his theory of relativity. (3) The moon was closer to the earth in 1960 than in 1930. (4) The moon watch could not be televised in 1930.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
3. By the end of the ninth grade, the learner will demonstrate awareness that scientific knowledge enhances man's ability to understand his environment, protect it and function in it, as measured by minimum criteria on an ORT.	
3.1 Given an environmental situation, the learner will identify those scientific activities which are most likely to be beneficial to man.	3.1a Given an artificial pond or lake, the learner will name three activities which would help to make the body of water productive of food for man. 3.1b Given a polluted river, the learner will name three activities which would help to make it a stream that is clean. 3.1c A stream flows through a town. Upstream people are dumping wastes into the stream and polluting it. Select the three best remedies from the list below and rank those three from most effective to the least effective. (1) Plant flowers along the edge of the river upstream of your town. (2) Divert the waste water from the towns upstream. (3) Dig a well to supply your town with water. (4) Divert the water into an artifiial lake before the town supply is taken from it. (5) Move your town to another (6) Pump your water supply from a nearby river. (7) Force the towns upstream to filter and treat waste water so that the stream is pure. (8) Put in a filtering and treatment plant for the stream water so that your town purifies the polluted river water before using it.
Scientific Literacy	
1. By the end of the ninth grade, the learner will demonstrate awareness that scientific knowledge is the result of man's attempt to interpret and communicate his observations of the universe in terms of hypotheses, theories, models and natural laws, as measured by minimum criteria on an objectives-referenced test (ORT).	
1.1 Given a set of statements on the nature of science, the learner will select the one which best matches a given definition of science.	1.1 One definition of science is: seeking, making and using knowledge. From the following, select one statement which least fills the given definition. (1) Science discoveries lead to an increase in technology. (2) Science is asking questions one at a time. (3) Science is a tool used to explain what is observed.

SCIENCE 7-9

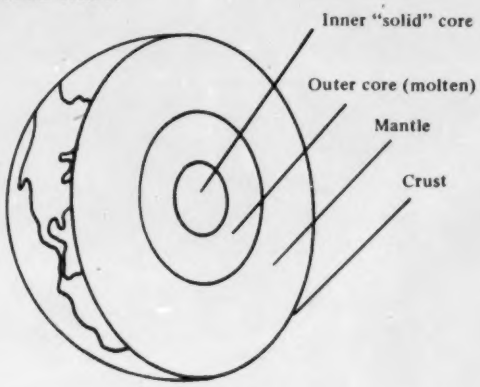
PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
1.2 Given the terms observation, hypotheses, and theory, the learner will select an ordering of these terms to match a given definition of scientific knowledge.	1.2 A definition of scientific knowledge is the following: Scientific knowledge is knowledge which had been discovered experimentally. From the list of terms given below select the order that best fits the definition given above. (1) observation, hypothesis and theory (2) hypothesis, theory, observation (3) theory, hypothesis, observation (4) theory, observation, hypothesis
2. By the end of the ninth grade, the learner will demonstrate awareness that scientific knowledge is gained through observation, investigation and experimentation, as measured by minimum criteria on an ORT.	
2.1 Given an account of the solution of a problem process in science, the learner will identify from an appropriate set of statements those which represent steps in the process of establishing scientific knowledge.	2.1 Given an account of new scientific research in a popular weekly magazine such as *Time*, the student will be able to identify one or more of the following: (1) the problem that was solved (2) the hypothesis that was tested (3) the evidence that was collected (4) The nature of the solution or conclusion that was reached.
3. By the end of the ninth grade, the learner will demonstrate awareness that science is a way devised by man for explaining the universe, as measured by minimum criteria on an ORT.	
3.1 Given a model for a situation, the learner will determine that there is a difference between the model and the reality.	3.1a Given a verbal description of the relationships of earth, moon, sun and stars to measure, the student will be able to express in his own words their relative sizes and their relative distances apart.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

3.1b Given a highway map, the learner will be able to tell approximately how long it will take to travel between cities.

3.1c



With reference to the figure:
The continental crust is made up of granitic material and the oceanic crust of basaltic material: their average thickness is about about 20 km.
The mantle is largely made up of iron magnesium silicates (dunite) and is approximately 300 km. thick.
The core is made up of nickel and iron in a fluid or semi-fluid state, and is approximately 3330 km. in radius. Which of the following statements are true (T) and which are false (F)?

(1) The figure accurately depicts the conditions in the earth.
(2) The crust of the earth is the same thickness all over.
(3) The boundary between the core and the mantle is a sharp line.
(4) The figure is to scale.
(5) The figure is an approximation of what the earth is like.
(6) The earth is a perfect sphere so that the dimensions are equal in whatever direction the radii are measured.

4. By the end of the ninth grade, the learner will demonstrate awareness that scientific knowledge or understanding should result in the increased respect for the effects of cultural phenomena, as measured by minimum criteria on an ORT.

4.1 After completion of the study of a body of scientific knowledge, the learner will be able to list three effects of a natural phenomena that may be harmful and three effects that will not be harmful.

4.1a After having read the popular literature on the human population problem, the learner will list:

(1) three effects that zero population growth would bring that would be beneficial to our present society.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
	(2) three effects that zero population growth would bring major changes in our present society that should be at least temporarily harmful.
	4.1b The learner will test three situations in which *fastened* automobile seat belts might contribute to personal safety, and three situations in which fastened automobile seat belts might be dangerous from the standpoint of personal safety.
	4.1c The learner will list three ways in which one-way streets may contribute to driving safety and three ways in which one-way streets may be dangerous.
	4.1d Given an eroded hillside field in an agricultural region, the learner will list three ways in which soil erosion is harmful from the standpoint of man's needs, and three ways in which soil erosion and consequent abandonment of fields may be beneficial to wild life and therefore helpful to man from the standpoint of recreation.
	4.1e Given rain falling on a non-rock, natural area, match conditions which will result in three instances that are harmful and three instances that are not. (1) No ground cover (2) Grass or crop ground cover (3) Forest ground cover (4) Steep slope (5) Gentle slope (6) Flat land (7) Torrential rainfall (8) "Hard" rainfall (9) Gentle rainfall (10) Snowfall (11) Contour plowing (12) "Up and down the hill" plowing
5. By the end of the ninth grade, the learner will demonstrate awareness that there is more than one way of viewing his (the learner's) own environment; as measured by minimum criteria on an ORT.	
5.1 Given an environmental situation, the learner will list at least two items that explain the situation.	5.1a Given an area of bare ground in the spring with earthworm burrows broken through the surface, ask the learner to list two environmental factors which encourage earthworm activity.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

5.1b After having observed the activities of birds at a feeding station, the learner will be able to identify two factors (other than food) that influence their activity.

5.1c A section of a Great Lakes shoreline in a popular vacation area is subject to erosion of the dunes on which most of the houses are built, with the sand being deposited in a channel from a harbor where boats are kept; the sand has a tendency to close the channel by silting.

The possible actions that can be taken in this situation are:

(1) Do nothing.
(2) Build a sea wall or other device to stop the cliff eroding — but then the beach will disappear, but the channel will remain open.
(3) Dredge the channel so that it will not silt up.
(4) Move the houses back from the cliff
(5) Pump up sand for a beach in the sheltered harbor.
(6) Make the area a wilderness, reserve, destroy all evidence of man, and forbid entrance.

Which two choices would you make if you were:

A taxpayer who had to pay for whatever was done _____

A boat owner _____

A house owner (on the cliff) _____

A vacationer _____

A fisherman _____

Yourself — who likes to swim off the beach _____

6. By the end of the ninth grade, the learner will demonstrate awareness of the differences between relevant and irrelevant details of an investigation, as measured by minimum criteria on an ORT.

6.1 Given a body of data related to an investigation, the learner will recognize differences between relevant and irrelevant data.

6.1a Given two comparative plants, grown in pots under different environmental conditions, and data describing the comparative growth behavior of the two plants, the learner will be able to identify the environmental conditions which have contributed to the differences.

PERFORMANCE OBJECTIVES

EXAMPLES AND COMMENTS

6.1b A solid object is observed to slide down a smooth plain as the inclination of the plane is increased. Which of the following are necessary to help explain the phenomenon.

(1) The object is white.
(2) The object is metal.
(3) The plane is wood.
(4) The plane is green.
(5) The plane is thick.
(6) The plane is tilted smoothly.
(7) The object has a hook on top.
(8) There is a pan of water at the bottom of the plane.
(9) the object is magnetic.
(10) The demonstration takes place on the floor.

7. By the end of the ninth grade, the learner will demonstrate awareness of man's need to understand science in our technological society, as measured by minimum criteria on an ORT.

7.1 Given a series of questions concerning events which have occurred in a technological society, the student will classify the scientific disciplines according to the questions.

7.1 Several questions can be asked concerning the changes caused and being caused by our increasingly technological society. Science is seeking answers to these questions, but science is composed of various special sections such as chemistry, earth science, biology, physics. Indicate which of these science sections apply to the questions listed below:

(1) Can we gain control of the weather in order to prevent flood and other climate catastrophies?
(2) Can we prevent earthquakes?
(3) Can we conquer disease?
(4) Can we find new sources of energy?

a. Physics
b. Biology
c. Chemistry
d. Earth Science

More than one section (physics, biology, etc.) may be used.

8. By the end of the ninth grade, the learner will recognize the interrelationships among science, technology and other facets of society, as measured by minimum criteria on an ORT.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
8.1 Given a societal problem in science, the learner will identify at least one relationship between science and technology and its implications on society.	8.1 Our society is facing a possible energy shortage. Which of the following would be least practical as a measure to meet this problem. (1) Limit the size and horse power of all automobiles. (2) Limit the construction of any more atomic energy plants. (3) Forbid the use of tractors in the production of food on farms. (4) Introduce gasoline and electricity rationing.
9. By the end of the ninth grade, the learner will value working collectively and cooperatively with other students, as measured by minimum criteria on an ORT.	
9.1 Given an appropriate scientific problem, the learner will choose to become involved in a team effort directed toward its solution.	9.1a Given a balanced aquarium, the learner will be able to function as a member of a team of four students who are asked to do the following: (1) Help plan a study of the interrelationships of the living organisms in the community. (2) Carry out his share of the periodic observations necessary to carry on the study. (3) Contribute to the framing of a diagram showing the interrelationships.
	9.1b You are part of a group conducting an investigation dealing with materials or objects, which is part of a scientific study. Which of the following will tend to result in a better understanding of the materials or objects, because more than one individual's opinion is available. (1) Each student will take one object or a part of the material and study it separately, and will not confer with others. (2) Each student will take all the objects in turn, and all the material in turn, study it separately and will not confer with others. (3) The students will repeat 1 and 2 in pairs discussing their findings. (4) The whole group will examine the objects and material and discuss them. (5) Each student will examine an object or part of the material, so that all of it is examined, and will express an opinion or give a report based on his examination, which will be discussed by the group.

PERFORMANCE OBJECTIVES	EXAMPLES AND COMMENTS
10. By the end of the ninth grade, the learner will demonstrate awareness of problems in science that need solutions, as measured by minimum criteria on an ORT.	
10.1 Given a body of contemporary literature, the learner will isolate three problems in science that need solutions.	10.1a From a systematic reading of the science news in a magazine such as *Time* for a period of six weeks, the learner will be able to list three scientific problems that are unsolved, and the kinds of studies that are being made in trying to solve them. 10.1b Pick an appropriate item that is of current interest in science, label several phrases and ask the learner to pick out three problems in science that need solutions.

Definitions

1. APPRECIATING—Understanding, valuing, accepting, and respecting one's fellow man, the works of man, and the works of nature.
2. CLASSIFYING—Sorting and grouping objects or events according to similarities and differences selected by the observer.
3. COMMUNICATING—Using the written and spoken word, graphs, drawings and diagrams as means of transmitting information and ideas to others.
4. CONCEPT—Categories or classes of objects and events, and of abstractions that can never be made concrete, such as, for example, *time*. Concept learning helps individuals classify.
5. CONDUCTING—The physical carrying out (such as carrying out an experiment or investigation.)
6. CONSTRUCTING—Is the building of physical or mental representation on the basis of a body of data.
7. CONTROLLING VARIABLES—Identifying the variables of a system and selecting from the variables those which are to be held constant and those which are to be manipulated in order to carry out a proposed investigation.
8. DEFINING OPERATIONALLY—Defining terms in the context of one's experiences, giving either a description or telling what to do and what to observe.
9. DESIGNING—Planning in detail, schematically.
10. DIFFERENTIATING—Separating or classifying into categories or groups.
11. DISTINGUISHING—Differentiating and describing the basis for classification.
12. EXPERIMENTING—Devising an original situation, that can be manipulated, in which a hypothesis is tested under controlled physical conditions.
13. FORMULATING HYPOTHESES—Constructing generalizations that include all objects or events of the same class.
14. GENERALIZING—Making a statement summarizing, an interpretive nature, on the basis of a body of data (similar to formulating hypotheses).
15. IDENTIFYING—Pointing out, pointing to or naming.
16. INFERRING—Explaining an observation or a set of observations.
17. INTERPRETING—Finding patterns among sets of data which lead to the construction of inferences, predictions, and hypotheses.
18. LISTING—Presenting a collection of information or observations. Also the act of compiling a collection of information or observations.
19. MANIPULATED VARIABLE—The variable which is graphed on the horizontal or X-axis.
20. MEASURING—Making quantitative observations with increasing precision and accuracy.
21. OBJECT—Anything that can be perceived by the senses (i.e., nail, book, wood, rabbit, tree, glasses, person, tennis ball, ant).
22. OBSERVING—Doing every imaginable thing in a situation and then judging the response through all the appropriate senses.
23. ORDERING—Arranging objects or events in a sequence according to a specific criterion (for example, length, weight, time, color, texture).
24. PERFORMANCE OBJECTIVE—Defines, in measurable terms, what the learner should be able to do or know after a certain sequence of instruction.
25. PREDICTING—Making specific forecasts of future observations based on inferences about relationship between or among related variables.
26. PROPERTIES—Perceptions which are received by the senses and which serve to describe objects and events.
27. RECOGNIZING—Receiving and responding to communicated information, situations and/or phenomena.
28. RESPONDING VARIABLE—The variable which is graphed on the vertical or Y-axis.
29. SELECTING—Choosing from a group or set according to specified criteria.
30. USING NUMBERS—Utilizing number concepts, simple graphs, and some algorithms in solving problems of a scientific nature.
31. USING SPACE/TIME RELATIONSHIPS—Describing spatial relationships and their change with time.

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